not very different from those of thundershowers. For comparison, four samples of raindrop pellets from general storms, taken during heavy rainfalls, were consulted, and the drops grouped, divided, and weighed in the same manner as in the case of the thundershower samples. The four samples contained 205 raindrops. But ten of these were of large size, though there were 46 of medium size. The number of small and very small drops numbered 149.

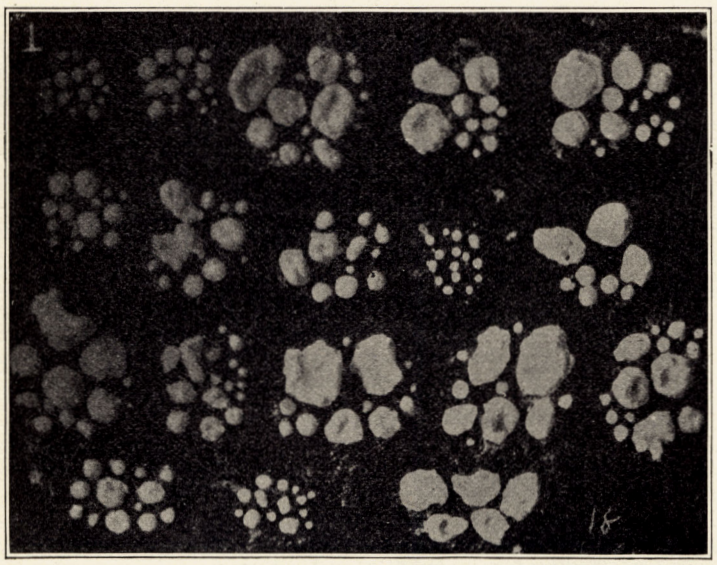

Fig. 11.—Great thundershower, newly forming, of August 14, 1904. This shower was accompanied by vivid and frequent lightning, and underwent many partial intermissions and renewals. Duration, fifty-five minutes.

The large and medium drops were grouped into one class, and the small and very small into another, and weighed. The former weighed 6 grains, troy, the latter 4 grains, troy. This would seem to indicate that the major portion of the rainfall, even during general rainstorms, emanates from great heights, and is probably traceable to snow origin. It is true that in making these estimates no allowance has been made for the liquid raindrops and aqueous material that, through merging and other processes, were probably added to and incorporated with those classed as of snow origin. This may sometimes, and in some instances, be considerable. But after making all due allowances for this and other uncertainties, the fact remains that the very large and possibly the major portion of the rainfall in all climes is due to the melting of snow flakes or granular snow. As having a bearing on this point, it may be well to quote Mr. Maxwell Hall, of Jamaica (see MONTHLY WEATHER REVIEW for May, 1904, page 230). Mr. Hall, referring to the expansion of the cumulus clouds and the conversion of their summits (while mushrooming out) into cirro-stratus clouds, says: "By means of a sextant it was found that the average heights of such well-formed rain producing cumuli was as much as six miles. At this elevation the temperature is below zero, and strato-cirrus must consist of fine snow. This fine snow ultimately falls by its own weight, and, melting, produces those gentle after rains that follow the heavy rains and squalls of the (central) cumulus." The photographs of thundershower raindrops in figs. 5 and 6 illustrate the general character of the rainfall of such showers as Mr. Hall describes. Groups 1 to 3 of fig. 5, and 1 to 6 of fig. 6, are typical of the heavy rains of the central cumuli, while 4 to 7 of fig. 5, and 7 and 8 of fig. 6 are typical of the gentle rains due to the melting of the snow crystals shed by the cirro-stratus clouds, such as Mr. Hall mentions. Sometimes such striated cirro-stratus clouds assume curious rounded flocculent shapes or convolutions, their under sides seeming, in fact, to bulge downward in places, and groups 4 to 7 of fig. 5 possess unusual interest, as they fell from flocculent, bulging, cirro-stratus clouds of this character.

In conclusion, it seems hardly necessary to add that the mechanism of rain formation and the phenomena connected therewith is of great interest and import, and should receive from scientists a larger measure of attention than hitherto.

It seems certain that systematic study of this and allied phenomena would, through the increase of our exact knowledge regarding it, richly repay patient and thoroughgoing investigation. Aerophiles, containing self-registering instruments, might, with advantage, be sent up into the clouds during various rainfalls, and the messages they would bring down would doubtless greatly increase our knowledge of the temperatures, humidity, electrical conditions, etc., of that mysterious cloudland realm, so rarely entered and of which we know so little. As yet we know not to a certainty the exact heights of the various rain-producing clouds or strata, or how far within the clouds above their bases precipitation first commences. Neither do we know the temperature or humidity within the various "lows" and "highs," or within thunder and storm clouds, nor the variations of these with corresponding altitudes within cloud-free regions outside storm areas. Our knowledge of the highest altitudes attained by the upper clouds within the various segments of general rainstorms is most unsatisfactory, and we know but little of the ultimate maximum altitudes to which water vapor ascends.

As Professor Abbe says, referring to recent balloon ascents in Europe, when heights of 10,000 to 20,000 meters were attained (MONTHLY WEATHER REVIEW, June, 1904, pp. 276–277):

> The air that descends in our areas of high pressure and that which flows out of the polar regions may come from the upper limits of the atmosphere, and with equal probability the air that ascends in our areas of low pressure may continue its journey upward to those same heights. * * * We at the bottom of the atmosphere are nearly as unconscious of the commotion above us as are the animals at the bottom of the ocean.

THE ADVANCEMENT OF METEOROLOGY.

By T. H. DAVIS.

In Prof. J. M. Pernter's letter, which appears in the May issue of the MONTHLY WEATHER REVIEW, there are two paragraphs that all sincere meteorologists should "read, mark, learn, and inwardly digest." Speaking on the discovery of the correct physical basis, he states:

> This basis will never be discovered by means of experiments in predictions, which are, for the most part, matters of personal judgment, but only *through long-continued, rigidly exact, genuine research*, with the aid of physical methods, by men equipped with a complete knowledge of physical, meteorological, and mathematical sciences.

Again he states:

> Work, hard and thorough work, for many years, and not a game of chance in experimental predictions, is what is required in this matter.

Scattered through the United States are a number of stations for the regular observations of meteorological phenomena. These are in charge of trained men, who regularly make observations of temperature, pressure, humidity, wind (direction and rate of travel), conditions of weather and so on, as directed by the Central Bureau in Washington. To these clever, educated men this work, speaking generally, must after a time become quite mechanical, and they must feel, after recording their observations, producing weather maps, and replying to numerous telephonic inquiries throughout the day, that those duties are all that is required of them, and really they should be, because they are more arduous than is generally supposed. For this reason it is only now and again, at long intervals, that we see any special investigation reported as having been made by any of the weather observers.

Now, all who are truly interested in meteorology possess an ardent desire to see it included in the realms of the exact sci-

ences, but it does not seem that it will make much progress thither so long as we are satisfied with "highs and lows" and supposed results which should mature from supposed absolute mathematical calculations. These latter are necessarily of the greatest possible value to the science, but it hardly seems that we shall arrive at a fundamental basis on these alone.

Hypotheses and theories whose nativity spring from deep mathematical calculation need much in the way of actual occurrence for their confirmation.

In meteorology we are dealing with a subject particularly profound and full of difficulties and easy snares. For example, consider the theories of cyclones and cyclone formation. Although these are considered to have been pretty well worked out, yet there seems to be no investigator who can state absolutely why cyclonic areas first appear on the western coast (mainly in the northwest), on the southern coast bounding the Gulf, or from the southeast. Neither can we find absolute facts which explain the varied paths of the western cyclones as they pass across our continent toward the Atlantic Ocean, nor have we any sure data for explaining their erratic rates of travel. All that seems to be attempted in this direction appears based on supposition and experience rather than on fixed and definite laws. The forecasters have certain rules on which to base their forecasts, but evidently these are not always justified by the facts. What, then, should be done to promote and maintain the dignity of meteorology as a science? Does it not seem that rigid research in other places than the Central Bureau is necessary?

It does seem that patient, qualified scientists, not necessarily civil servants by examination, devoted to the science, should be appointed in selected districts to make research into the meteorological phenomena and weather conditions for that specific locality, to record their results, and periodically make report of results as based on actual occurrences. These, passed on to the Central Bureau, could be further studied, and hypothetical reasoning would be proved or disproved by contact with the phenomena that have actually occurred as carefully observed over a period of time. Research, patient and faithful observation by independent men, as above outlined, would do very much in methods by which fundamental principles could be accurately established. Accident will never bring them, for the subject is too abstruse to admit of anything of the kind.

What ought to occur under certain conditions, and what does occur, are too often at variance, and it is for the maintenance of the conformity of these two conditions that devoted meteorologists should use all their energy and thought, together with true and faithful observation of actual facts.

THUNDERSTORMS AT TAMPA, FLA.

By JOSEPH BILY, JR., Assistant Observer.

Thunderstorms at Tampa, may be divided into two classes; those of the summer, which occur from May to September and are of great frequency, and those of the cooler months, which are distributed from October to April and are of but occasional occurrence. Storms of the former class are in nearly all cases of local origin, due to the convectional overturning of ascending air currents, but the thunderstorms of the winter type present a different character, and accompany cyclonic areas which drift eastward from Texas or the west Gulf of Mexico, and whose centers pass from 200 to 500 miles to the northwestward of Tampa.

During the summer months cyclonic disturbances are of rare occurrence in this region, being confined to northern latitudes. The cyclones of the West Indies, after recurving from their westerly course in West Indian waters, generally pass northward so far to the east as to give Tampa fair weather; or, when continuing on their westward drift and crossing the Gulf of Mexico, their centers are such a distance to the south and west of Tampa that only occasional showers are experienced. When the centers of these storms pass in proximity to Tampa heavy rains and high winds result. Thus we see that but for the frequent occurrence of local thunderstorms in the summer the sources of rain are limited. The geographical form and location of central and southern Florida, a peninsula surrounded by large bodies of water, admit of this pronounced summer type of climate. There is thus a daily interchange of air between land and sea, except when interrupted by movements of vast eddies in the atmosphere, known as areas of high and low pressure.

The summer thunderstorms are noticeably mild when compared with those of a continental climate. The thunder is not loud, but a copious rainfall is a characteristic that may always be observed. These conditions seem to be the reverse of those in the interior and northern portions of the United States, where but little rain accompanies a mild thunderstorm, the heavy or copious rainfall being a marked feature of the severe thunderstorms of those regions.

During the warm season of the year when weather conditions are dominated by a permanent area of high pressure off the south Atlantic coast, the prevailing winds over west-central Florida are from south to east. The nights, as a rule, are clear after 10 p. m., but with the rising of the sun in the morning the lower stratum of air becomes rapidly heated, causing ascending currents, and by 7 a. m. cumulus "rolls" are seen springing into life on the horizon. These white "ball-like" clouds increase in number and size during the forenoon, and become in the early afternoon closely packed masses, from the edges of which protrude miniature mountain peaks or overgrown cumulus clouds with evident augmentation or "bubbling over" at the summit. Up to the time of maximum cloudiness the atmosphere is sultry and oppressive, but with the breaking of the storm and the downpour of rain, attended by a gust of wind, the temperature falls several degrees, which, with the decrease in humidity, produces an interval of relief. After the storm the clouds break away to some extent; the sun comes out, evaporating the fallen rain; the temperature tends to rise to its normal, and again the atmosphere is as sultry and oppressive as before the storm. The sky continues partly cloudy till evening, when the clouds decrease and disappear in the early night, while the air becomes cool and comparatively refreshing.

These storms have their greatest frequency in the afternoon, but occur in the forenoon as well as early night. Their prevailing movement is from the eastern quadrant, with a secondary frequency from the southern quadrant. They have, however, been noticed to move from all points of the compass, and at times the storm appears to be stationary. Nor are they of great diameter. There have been several occurrences of heavy rain accompanying these "locals" over the southern section of the city while in the northern portion only a trace or no rain fell; and a reverse of these conditions has also been known, all depending on the location and direction of movement of the center of the storm. As many as four distinct and separate thunderstorms have been noticed at the same time.

During the past fourteen years, 1890–1903, there have been six days with three thunderstorms occurring at various portions of the same day, and forty-two days with two such occurrences, distributed as follows:

Thunderstorms.	May.	June.	July.	August.	September.
Three in one day	0	4	1	1	0
Two in one day	4	11	17	10	0

The damage caused by the storms of the summer type is light,